

15-DEZ-2003 23:30

W OTTESEN PATENT ATTORNEY

+49 4523 988143

S.01

WALTER OTTESEN  
PATENT ATTORNEY

P.O. BOX 4026  
GAITHERSBURG, MARYLAND 20885-4026

TELEPHONE: (301) 869-8950

TELECOPIER: (301) 869-8929

RECEIVED  
CENTRAL FAX CENTER

DEC 15 2003

OFFICIAL

TELECOPIER TRANSMISSION COVER SHEET

<u>12-15-2003</u>	<u>S. N. 10/025,605</u>	<u>1-703-872-9318</u>
Date	File	Telecopier Number

To: Examiner Peter B. Kim

United States Patent and Trademark Office

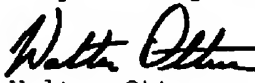
Group Art Unit 2851

From: Walter Ottesen

Number of Sheets (including cover sheet) Twentyfour (24)

Message: A literal translation of German patent application 100 64 685.9 is submitted herewith in support of an amendment filed in patent application serial no. 10/025,605.

Respectfully submitted,

  
Walter Ottesen  
Reg. No. 25,544

Certificate of Transmission

I hereby certify that this correspondence is being facsimile transmitted to the Patent and Trademark Office (Fax No. 703-872-9318) on December 15, 2003.

  
Walter Ottesen

In the United States Patent and Trademark Office

Applicants: K. Schuster et al

Group Art Unit: 2851

Patent Application

Serial No: 10/025,605

Examiner: Peter B. Kim

Filed: December 26, 2001

Attorney Docket: 00119

For: Lithographic Objective  
having a First Lens  
Group including only  
Lenses having a  
Positive Refractive Power

RECEIVED  
CENTRAL FAX CENTER

DEC 15 2003

OFFICIAL

Verification of Translation

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English language and in the language of the certified German patent application 100 64 685.9 and I believe the attached English translation to be a true and complete translation of this document.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of the translator: Walter OttesenDate: 12/15/03

Signature of the translator:



Post Office Address: P.O. Box 4026  
Gaithersburg, Maryland 20885-4026

FEDERAL REPUBLIC OF GERMANY

Priority Certification as to the Filing  
of a Patent Application

Serial Number: 100 64 685.9  
Filing Date: December 22, 2000  
Applicant/Owner: Carl Zeiss, Heidenheim/DE  
Title: Lithographic Objective having a First  
Lens Group including only Lenses having a  
Positive Refractive Power  
IPC: G 02 B 13/00

The attached papers are a true and correct copy of the  
original papers of this patent application.

Munich, October 5, 2001  
German Patent and Trademark Office  
The President

/ embossed seal  
of German Patent  
Office/

by  
(signature)  
  
(Stamp:) Brand

A 9161  
03/00  
EDV-L

Attorney Docket No: 00119

Lithographic Objective having a First Lens Group including  
only Lenses having a Positive Refractive Power

5 The invention relates to a projection objective for  
microlithography which has at least two lens groups which have  
positive refractive power.

United States Patent 5,990,926 discloses a projection lens  
system for use in microlithography and this lens system has three  
bellied regions, that is, three lens groups of positive  
10 refractive power. The objective is viewed in the direction of  
the propagation of the light. Here, the first lens group  
includes only positive lenses and the wafer end numerical  
aperture is 0.6.

United States Patent 5,969,803 discloses a projection  
15 objective for use in microlithography and this lens system  
includes three positive lens groups. The numerical aperture  
again is 0.6 and the objective here is a purely spherical  
objective.

European patent 0,332,201 discloses an optical projection  
20 system for microlithography wherein, at the wafer end, the last  
two lenses have respective aspherical lens surfaces for improving  
imaging quality. The aspherical lens surfaces are arranged  
facing toward each other.

The projection systems known from the above European patent  
25 are provided for photolithography and correspondingly have a low  
number of lenses. The imaging quality attainable therewith does  
not meet the requirements which are imposed on projection systems  
for microlithography. Especially, the numerical aperture, which  
can be made available by means of this objective, is only 0.45.

30 The task of the invention is to provide a projection

objective for microlithography which has a high numerical aperture as well as excellent imaging qualities.

The task of the invention is solved by the features of claim 1.

5           A projection objective is provided which has an especially high numerical aperture while at the same time having a low structural length because of the measure to configure a first lens group in such a manner that this lens group comprises only lenses of positive refractive power and the number of lenses of  
10           positive refractive power of the first lens group is less than the number of the positive lenses which are mounted forward of the diaphragm of the additional lens group of positive refractive power.

          In the input region of the objective, an expansion of the  
15           input beam is avoided by providing the first lens group which has only lenses of positive refractive power. Because of this measure, this first lens group can be configured to be very slim, that is, the lenses have a small diameter. In this way, less material is needed in the first lens group, on the one hand, and,  
20           on the other hand, the structural space, which is needed to accommodate this lens group, is reduced. This structural space can be used to increase the numerical aperture by providing additional positive lenses forward of the diaphragm.

          For an especially slimly configured first lens group, it is  
25           possible to shift the Petzval correction into these follow-on lens groups of positive refractive power because of the structural space obtained with a slight enlargement of these follow-on lens groups of positive refractive power. An especially large contribution to the Petzval correction is  
30           supplied by the positive lens group in which the diaphragm is

mounted in combination with the strong beam narrowing forward of this group via a strong negative refractive power.

Preferably, the diameter of the lenses of the first lens group is less than 1.3 times the object field.

5           It has been shown to be advantageous to provide at least one lens having an aspheric surface in the first lens group. This aspheric surface contributes to improving the imaging quality of the objective.

10           It has been shown to be advantageous to provide aspheric lens surfaces in the first lens group which deviate by more than 300  $\mu\text{m}$  compared to the best fitting spherical lens surface. The arrangement of such an asphere on the object end lens surface of the first lens of the lens arrangement has been shown to be advantageous. These intense asphericities close behind the  
15           reticle are necessary and are especially effective in order to correct the field-dependent aberration. The extent of the asphericity is dependent upon the beam cross sections and on the input aperture which is always less than the output aperture. Even though the deviation to the sphere is great, a simple  
20           asphere form generates the most favorable contribution to the total aberration correction. As a consequence of the simple asphere form, this asphere form remains nonetheless easy to manufacture.

25           Further advantageous measures are described in further dependent claims.

The invention is described in detail with reference to some embodiments.

FIG. 1 is a schematic showing the assembly of a projection exposure system;

30           FIG. 2 is a projection objective for 248 nm having a

numerical aperture of 0.8;

FIG. 3 is a projection objective for 193 nm having a numerical aperture of 0.8; and,

FIG. 4 is a projection objective for 248 nm having a numerical aperture of 0.8.

First, the configuration of a projection exposure system will be described with reference to FIG. 1. The projection exposure system 1 includes an illuminating unit 3 and a projection objective 5. The projection objective 5 includes a lens arrangement 19 having an aperture diaphragm AP. An optical axis 7 is defined by the lens arrangement 19. Different lens arrangements are explained hereinafter with reference to FIGS. 2 and 3. A mask 9 is mounted between the illuminating unit 3 and the projection objective 5 and the mask is held in the beam path with the aid of a mask holder. Masks 9 used in microlithography have a micrometer-nanometer structure. This structure is imaged on an image plane 13 by means of the projection objective 5 demagnified up to a factor of 10 (demagnified especially by a factor of 4). A substrate 15 or a wafer, which is positioned by a substrate holder 17, is held in the image plane 13.

The minimal structures, which can still be resolved, are dependent upon the wavelength  $\lambda$  of the light, which is used for the illumination, as well as on the image-end numerical aperture of the projection objective 5. The maximum achievable resolution of the projection exposure system 1 increases with a decreasing wavelength  $\lambda$  of the illuminating unit 3 and with an increasing image-end numerical aperture of the projection objective 5.

In FIG. 2, a projection objective for microlithography is shown. This objective includes six lens groups.

The first lens group includes three positive lenses L101 to L103, which are all biconvex. The last lens L103 is provided with an asphere on the image-end surface. A targeted correction of the coma in the region of the image field zone is possible via the aspheric surface provided forward of the first waist or narrowing. The aspheric lens surface has only a slight influence on the inclined spherical aberration in the tangential section and in the sagittal section. In contrast, the inclined sagittal aberration (especially in the region between the image field zone and the image field edge) can be corrected with the aspherical lens surface after the narrowing or waist.

The provision of a second aspherical lens surface is a valuable measure in order to counter, with an increased aperture, a reduction of the image quality based on coma.

The second lens group includes four lenses L104 to L107. The image-end mounted lens surface of this last lens L107 of the second lens group includes an aspheric lens surface. By means of this aspheric lens surface, especially a correction of image aberrations in the region between the image field zone and the image field edge is possible. The aberrations of higher order, which become noticeable with the observation of sagittal sections, are corrected. This is an especially valuable contribution because these aberrations, which are apparent in the sagittal section, are especially difficult to correct.

The third lens group includes the lenses L108 to L111. This lens group has a positive refractive power. The last image-end disposed lens surface of the last lens of this group is aspheric. This asphere operates, on the one hand, advantageously on the coma and, on the other hand, this asphere operates in a correcting manner on the axial aberration and on the inclined



spherical aberration. The correction of the aberration is especially possible because of the large beam diameter in the region of this aspheric surface.

5 The following lens group having the lenses L112 to L115 has a negative refractive power.

The lens group following the above has a positive refractive power and includes lenses L116 to L123. A diaphragm is mounted in this lens group and this diaphragm is provided after the lens L119 so that four lenses of positive refractive power are  
10 mounted forward of the diaphragm. The excellent correction of the aberrations of this objective is attributable primarily to the positive lenses forward of the diaphragm. These lenses have a large component focal length because of the large diameter thereof, whereby the field loading drops and an improved  
15 correction at a higher numerical aperture is possible. These positive lenses operate, inter alia, advantageously on the coma. Furthermore, this lens group is characterized by a reduced number of lenses.

The sixth and last lens group includes the lenses L124  
20 to L127. The precise data of the lenses are presented in Table 1. The image field is 8 x 26 mm. It is noted that this objective has a very significantly high numerical aperture and yet has only 27 lenses. The required space for this objective is 1000 mm. The precise lens data are presented in Table 1.  
25

Table 1

Lenses	Radius		Thickness	Material	½ Lens Diameter	Refractive Index at 248 nm
0	infinite		20.9706	L710	61.246	0.999982
L101	1160.20105		13.5756	SIO2	66.130	1.508373
	-363.46168		0.7500	L710	66.788	0.999982
L102	256.92295		20.1184	SIO2	68.174	1.508373
	-429.93637		0.7500	L710	67.973	0.999982
L103	353.94471		15.3795	SIO2	66.245	1.508373
	-1064.34630	A	0.7500	L710	65.385	0.999982
L104	365.62225		10.0788	SIO2	62.164	1.508373
	150.28204		24.6344	L710	57.665	0.999982
L105	-160.21163		7.0000	SIO2	57.121	1.508373
	138.69010		27.4314	L710	57.066	0.999982
L106	-257.68200		7.0000	SIO2	57.709	1.508373
	280.52202		27.7747	L710	62.688	0.999982
L107	-122.86419		7.000	SIO2	64.152	1.508373
	-524.02005	A	21.2270	L710	75.975	0.999982
L108	-334.99360		27.7619	SIO2	88.903	1.508373
	-142.00372		0.7500	L710	92.514	0.999982
L109	-1079.51219		40.8554	SIO2	109.187	1.508373
	-172.00795		0.7500	L710	111.327	0.999982
L110	438.67858		43.4000	SIO2	122.583	1.508373
	-378.94602		0.7500	L710	122.708	0.999982
L111	162.47382		51.1885	SIO2	113.015	1.508373
	-5736.26278	A	0.7500	L710	110.873	0.999982
L112	165.15494		14.7530	SIO2	92.577	1.508373
	110.95539		37.6018	L710	79.631	0.999982
L113	-2352.60464		7.0000	SIO2	78.360	1.508373
	158.84317		34.9167	L710	71.086	0.999982
L114	-168.34448		7.0000	SIO2	70.590	1.508373
	245.44885		39.3735	L710	71.824	0.999982
L115	-113.75821		7.0000	SIO2	72.408	1.508373

		666.85880		23.5469	L710	88.173	0.999982
	L116	-278.47485		16.7462	SIO2	90.415	1.508373
		-195.62311		0.75000	L710	95.097	0.999982
	L117	1596621.30490		37.6629	SIO2	113.071	1.508373
5		-223.02293		0.7500	L710	115.353	0.999982
	L118	2651.21287		31.3744	SIO2	127.060	1.508373
		-371.06734		0.7500	L710	128.117	0.999982
	L119	1313.12466		25.1961	SIO2	131.302	1.508373
		-666.16100		0.0		131.498	1.000000
10		infinite		9.5632	L710	130.856	0.999982
	Diaphragm			0.0		130.856	
	L120	812.62806		22.4028	SIO2	132.498	1.508373
		-1458.91764		10.9629	L710	132.481	0.999982
	L121	344.45037		42.1137	SIO2	130.307	1.508373
15		-765.47811		20.1268	L710	129.380	0.999982
	L122	-250.24553		7.000	SIO2	127.451	1.508373
		-632.30447		15.5964	L710	127.304	0.999982
	L123	-398.61314		20.5840	SIO2	126.393	1.508373
		-242.62300		1.2010	L710	126.606	0.999982
20	L124	143.95358		37.1050	SIO2	103.455	1.508373
		419.96225		0.8946	L710	100.698	0.999982
	L125	120.37736		30.9217	SIO2	85.039	1.508373
		263.87928		14.8885	L710	79.055	0.999982
	L126	1886.79345		7.6305	SIO2	74.319	1.508373
25		277.58693		3.7474	L710	65.935	0.999982
	L127	144.27214		50.1938	SIO2	58.929	1.508373
		423.41846		15.0000	L710	32.250	0.999982
	0'	infinite		0.0001	L710	13.602	*
30							

L710 is air at 950 mbar.

Asphere L103:

EX= 0

C1=  $-0.10457918 \cdot 10^{-6}$

Asphere L107:

EX=  $0.4532178 \cdot 10^2$

C1=  $0.19386780 \cdot 10^{-7}$

$$C2= 0.37706931 \cdot 10^{-11}$$

$$C2= -0.22407622 \cdot 10^{-11}$$

$$C3= 0.61848526 \cdot 10^{-16}$$

$$C3= -0.42016344 \cdot 10^{-15}$$

$$C4= -0.13820933 \cdot 10^{-19}$$

$$C4= 0.45154959 \cdot 10^{-19}$$

$$C5= 0.36532387 \cdot 10^{-24}$$

$$C5= -0.19814724 \cdot 10^{-23}$$

$$5 \quad C6= -0.11262277 \cdot 10^{-28}$$

$$C6= -0.43279363 \cdot 10^{-28}$$

Asphere L111:

EX= 0

$$C1= 0.57428624 \cdot 10^{-8}$$

$$C2= 0.22697489 \cdot 10^{-12}$$

$$10 \quad C3= -0.71160755 \cdot 10^{-18}$$

$$C4= -0.72410634 \cdot 10^{-21}$$

$$C5= 0.32264998 \cdot 10^{-25}$$

$$C6= 0.55715555 \cdot 10^{-30}$$

The aspheric surfaces are described by the equation:

$$15 \quad P(h) = \frac{\delta \cdot h \cdot h}{1 + \sqrt{1 - (1 - EX) \cdot \delta \cdot \delta \cdot h \cdot h}} + C_1 h^4 + \dots + C_n h^{2n+2} \quad \delta = 1/R$$

wherein: P is the arrow height as a function of the radius h (height to the optical axis 7) with the aspherical constants  $C_1$  to  $C_n$  presented in Table 1; R is the apex radius and is given in the tables.

In FIG. 2, a projection objective is shown for the wavelength 193 nm and has a numerical aperture of 0.8. A field of 8 x 26 can be exposed by means of this objective. The required structural space of this objective is 1000 mm.

25 The first lens group includes only two positive lenses and both are biconvex. The first lens L201 of this lens group G1 is provided with an aspheric lens surface at the object end.

The second lens group G2 includes the lenses L203 to L205. The lens L203 is provided with an aspheric lens surface at the object end. Because of the two aspheric lens surfaces of the

lenses L201 and L203, which are provided in the first and second lens groups (G1, G2), respectively, and are arranged so as to be close to the field, an excellent beam separation in the input region of the objective is obtained. The arrangement of the aspheric lens surfaces on the side, which faces to the object, affords the advantage that the lenses, which have an aspheric lens surface, lie with the spherical lens surface against a lens frame. In this way, an excellent contact engagement on the lens frame with the spherical lens surface can be more easily ensured.

5 The third lens group G3 includes the lenses L206 to L210. This lens group has a positive refractive power. The two lenses L208 and L209 have two surfaces greatly curved toward each other. The last lens L210 of this lens group includes, at the image end, an aspheric lens surface. An excellent coma correction can be carried out by means of this aspheric lens surface. Furthermore, a correction of the axial and inclined spherical aberrations is especially possible in this region because of the large beam diameters.

15 The fourth lens group includes lenses L211 to L214. This lens group overall has a negative refractive power. In the next and fifth lens group G5, which includes the lenses L215 to L220, the diaphragm is mounted after the lens L217. This lens group includes three positive lenses and the last lens forward of the diaphragm is configured to be especially thick. The last lens group G6 includes the lenses L221 to L225 and the lens L224 is configured to be especially thick. An intense spherical overcorrection is obtained with this lens.

The precise lens data is presented in Table 2.

Table 2

	Lenses	Radius		Thickness	Material	½ Lens Diameter	Refractive Index at 193 nm
5	0	infinite		32.7500	L710	61.249	0.999982
	L201	469.70813	A	14.5480	SIO2	62.591	1.560289
		-20081.10295		5.1612	HE	63.071	0.999712
	L202	354.86345		18.8041	SIO2	63.983	1.560289
10		-334.15750		9.4004	HE	63.889	0.999712
	L203	381.44025	A	28.0599	SIO2	61.107	1.560289
		140.16853		27.1615	HE	55.898	0.999712
	L204	-149.89590		23.2652	SIO2	55.910	1.560289
		229.41466		33.1065	HE	62.024	0.999712
15	L205	-105.40274		7.0000	SIO2	63.462	1.560289
		-336.55620		16.9549	HE	74.238	0.999712
	L206	-165.03805		10.7419	SIO2	78.416	1.560289
		-147.21753		0.7575	HE	82.164	0.999712
	L207	-314.39712		27.7710	SIO2	90.707	1.560289
20		-145.41305		0.7500	HE	94.176	0.999712
	L208	-50326.68803		38.7705	SIO2	107.592	1.560289
		-211.33124		0.7500	HE	109.537	0.999712
	L209	184.32395		41.8364	SIO2	112.438	1.560289
		1282.45923		0.7500	HE	110.470	0.999712
25	L210	153.97703		35.8150	SIO2	99.821	1.560289
		538.04124	A	8.4636	HE	95.507	0.999712
	L211	180.72102		7.8641	SIO2	82.558	1.560289
		116.94830		38.5761	HE	73.768	0.999712
	L212	-292.06054		7.0000	SIO2	71.989	1.560289
30		121.89815		26.8278	HE	65.096	0.999712
	L213	-416.86096		7.0000	SIO2	65.191	1.560289
		320.06306		34.0097	HE	66.681	0.999712
	L214	-106.74033		7.1599	SIO2	67.439	1.560289
		842.66128		12.4130	HE	82.767	0.999712
35	L215	-531.44217		35.2270	SIO2	84.311	1.560289

		-173.85357		0.7500	HE	93.111	0.999712
	L216	5293.05144		34.6817	SIO2	109.462	1.560289
		-359.30358		5.8421	HE	114.271	0.999712
	L217	1423.10335		73.8658	SIO2	123.709	1.560289
5		-302.64507		11.7059	HE	130.054	0.999712
		infinite		-4.1059	HE	129.751	0.999712
		infinite		0.0000		129.751	
	L218	644.68375		29.3314	SIO2	130.947	1.560289
		-1224.04524		0.7500	HE	130.998	0.999712
10	L219	324.02485		28.7950	SIO2	129.211	1.560289
		1275.35626		44.6599	HE	127.668	0.999712
	L220	-246.29714		25.7695	SIO2	126.964	1.560289
		-260.21284		0.7500	HE	129.065	0.999712
	L221	265.62632		25.9894	SIO2	115.965	1.560289
15		689.74229		1.8638	HE	113.297	0.999712
	L222	148.08236		25.7315	SIO2	100.768	1.560289
		256.32650		14.8743	HE	97.685	0.999712
	L223	130.15491		28.8792	SIO2	81.739	1.560289
		554.81058		6.6463	HE	77.855	0.999712
20	L224	infinite		67.6214	CAF2HL	76.291	1.501436
		infinite		0.9000	HE	33.437	0.999712
	L225	infinite		4.0000	SIO2	32.220	1.560289
	0'	infinite			L710	29.816	0.999982

25 L710 is air at 950 mbar.

Asphere L201:

EX= 0

C1=  $0.98184588 \cdot 10^{-7}$

C2=  $-0.34154428 \cdot 10^{-11}$

30 C3=  $0.15764865 \cdot 10^{-15}$

C4=  $0.22232520 \cdot 10^{-19}$

C5=  $-0.79813714 \cdot 10^{-23}$

C6=  $0.71685766 \cdot 10^{-27}$

Asphere L203:

EX= 0

C1=  $0.26561042 \cdot 10^{-7}$

C2=  $0.78262804 \cdot 10^{-12}$

C3=  $-0.24383904 \cdot 10^{-15}$

C4=  $-0.24860738 \cdot 10^{-19}$

C5=  $0.820928858 \cdot 10^{-23}$

C6=  $-0.85904366 \cdot 10^{-27}$

Asphere L210:

EX= 0

C1= 0.20181058\*10<sup>-7</sup>C2= -0.73832637\*10<sup>-12</sup>5 C3= 0.32441071\*10<sup>-17</sup>C4= -0.10806428\*10<sup>-21</sup>C5= -0.48624119\*10<sup>-25</sup>C6= 0.10718490\*10<sup>-2</sup>

10 In FIG. 4, a further lens arrangement 19 is shown which is designed for the wavelength 248 nm. This lens arrangement includes 25 lenses which can be subdivided into six lens groups. The structural length of this lens arrangement from object plane 0 to image plane 0' is 1000 mm. The numerical aperture of this lens arrangement is 0.8 of the image end.

15 The first lens group G1 includes two positive, biconvex lenses L301 and L302. The lens L301 is provided with an aspheric lens surface at the object end.

20 The second lens group G2 has negative refractive power and includes the lenses L303 to L305. The lens L303 is provided with an aspherical lens surface at the object side. An excellent correction of field aberrations is possible with these two aspheric lens surfaces of the lenses L301 and L303. Furthermore, a clear beam separation is achieved because of these aspheres mounted close to the field.

25 The third lens group G3 includes the lenses L306 to L310 and has a positive refractive power. The lens L310 is provided with an aspheric lens surface at the image end. By means of this aspheric lens surface, an especially good correction of the coma and the axial and inclined spherical aberrations is possible. An  
30 arbitrated correction between axial and inclined spherical



aberrations is especially possible because of the large beam diameters which are, however, significantly less than the clear lens diameters.

5 The fourth lens group G4 comprises the lenses L311 to L314 and has a negative refractive power.

The fifth lens group G5 includes the lenses L315 to L320 and has an overall positive refractive power. A diaphragm AP is mounted after the lens L317. By providing the clear air space between lens L317 and lens L318, it is possible to arrange a  
10 slide diaphragm between these two lenses.

The sixth lens group G6 includes the lenses L321 to L325. This lens group likewise has a positive refractive power. The meniscus lenses L321 to L323 are curved on both sides toward the object. This lens group includes only concave lenses which  
15 effect a field-independent, intense spherical overcorrection. For objectives having a high aperture, a correction of the spherical aberration also of higher order is possible by means of such conversion lenses.

This objective is especially well corrected especially  
20 because of the use of the aspheric lens surfaces as well as because of the specific arrangement of the number of positive lenses of the first lens group and because of the higher number of positive lenses forward of the diaphragm. The deviation from the wavefront of an ideal spherical wave is a maximum of 5.0 mλ  
25 for a wavelength of 248 nm.

Preferably, the aspheric lens surfaces are arranged on the forward lens surface whereby the corresponding lens lies with its spherical lens surface on the frame surface. In this way, these aspherical lenses can be framed with standard frames.

30 The precise lens data are presented in Table 3.

Table 3

M1652a						
	SURFACE	RADII	THICKNESSES	GLASSES	REFRACTIVE INDEX 248.338 nm	1/2 FREE DIAMETER
5	0	infinite	32.750000000	L710	0.99998200	54.410
	1	480.223886444 AS	16.335451604	SIO2	1.50839641	62.519
	2	-1314.056977504	2.406701682	L710	0.99998200	63.128
	3	329.047567482	20.084334424	SIO2	1.50839641	63.870
	4	-305.091682732	4.977873027	L710	0.99998200	63.737
10	5	383.800850809 AS	34.498893572	SIO2	1.50839641	61.345
	6	132.468446407	27.572735356	L710	0.99998200	54.949
	7	-146.238861297	7.000000000	SIO2	1.50839641	54.908
	8	202.067070373	26.902804948	L710	0.99998200	58.294
	9	-124.60415239	7.000000000	SIO2	1.50839641	59.529
15	10	-9484.579900199	32.328722869	L710	0.99998200	69.147
	11	-199.920035154	13.239699068	SIO2	1.50839641	80.852
	12	-156.061108055	0.750000376	L710	0.99998200	84.387
	13	-647.599685325	32.765465982	SIO2	1.50839641	96.077
	14	-169.327287667	0.750000000	L710	0.99998200	99.492
20	15	54987.154632328	43.791248851	SIO2	1.50839641	110.237
	16	-198.179168899	0.750000000	L710	0.99998200	112.094
	17	179.965671297	37.961498762	SIO2	1.50839641	110.618
	18	730.008903751	0.750000000	L710	0.99998200	108.526
	19	155.802150060	40.190627192	SIO2	1.50839641	99.471
25	20	525.570694901 AS	3.398727679	L710	0.99998200	93.056
	21	210.625893853	10.671567855	SIO2	1.50839641	85.361
	22	118.365024068	39.388505884	L710	0.99998200	74.596
	23	-290.993996128	7.000000000	SIO2	1.50839641	72.941
	24	153.643732808	24.440280468	L710	0.99998200	67.256
30	25	-364.763623225	7.000000000	SIO2	1.50839641	67.177
	26	201.419421908	40.566258495	L710	0.99998200	68.276
	27	-109.336657265	7.000000000	SIO2	1.50839641	69.319
	28	1061.293067334	13.765515688	L710	0.99998200	84.656
	29	-569.739152405	43.187833722	SIO2	1.50839641	87.749

	30	-187.461049756	0.750000000	L710	0.99998200	99.718
	31	1880.153525684	40.009394091	SIO2	1.50839641	117.515
	32	-286.975850149	0.750000000	L710	0.99998200	120.535
	33	1960.535354230	35.788625356	SIO2	1.50839641	127.909
5	34	-378.322213808	11.705900000	L710	0.99998200	129.065
	35	infinite	-4.105900000	L710	0.99998200	129.546
	36	665.988216308	27.299895961	SIO2	1.50839641	130.708
	37	-1514.956732781	0.750000000	L710	0.99998200	130.863
	38	392.166724592	35.529695156	SIO2	1.50839641	130.369
10	39	-2215.367253951	37.377386813	L710	0.99998200	129.155
	40	-235.632993037	38.989537996	SIO2	1.50839641	128.458
	41	-252.020337993	0.835229633	L710	0.99998200	131.819
	42	269.631401556	32.688617719	SIO2	1.50839641	118.998
	43	1450.501345093	0.750000001	L710	0.99998200	116.187
15	44	138.077824305	29.652384517	SIO2	1.50839641	100.161
	45	255.416969175	2.589243681	L710	0.99998200	96.793
	46	139.090220366	30.752909421	SIO2	1.50839641	86.930
	47	560.532964454	8.142484947	L710	0.99998200	82.293
	48	infinite	73.619847203	SIO2	1.50839641	79.524
20	49	infinite	0.900000000	L710	0.99998200	33.378
	50	infinite	4.000000000	SIO2	1.50839641	32.173
	51	infinite	12.000000000	L710	0.99998200	29.666
	52	infinite				13.603

25 L710 is air at 950 mbar.

#### ASPHERIC CONSTANTS

30	SURFACE NO. 1		
	EX 0.0000	C1	9.53339646e-008
	C2 -3.34404782e-012	C3	1.96004118e-016
	C4 8.21742864e-021	C5	-5.28631864e-024
	C6 4.96925973e-028	C7	0.00000000e+000
35	C8 0.00000000e+000	C9	0.00000000e+000
	SURFACE NO. 5		

5	EX	0.0000	
	C1	2.89631842e-008	C2 7.74237590e-013
	C3	-2.72916513e-016	C4 -8.20523716e-021
	C5	4.42916563e-024	C6 -5.10235191e-028
	C7	0.00000000e+000	C8 0.00000000e+000
	C9	0.00000000e+000	
	SURFACE NO.	20	

10 Ex 0.0000  
 C1 1.99502967e-008  
 C2 -7.64732709e-013  
 C3 3.50640997e-018  
 C4 -2.76255251e-022  
 C5 -3.64439666e-026  
 15 C6 5.10177997e-031  
 C7 0.00000000e+000

Patent Claims:

1. Projection objective including a first lens group (G1) of positive refractive power, a second lens group (G2) of negative refractive power and at least one additional lens group having positive refractive power, which has a diaphragm mounted therein  
5 and wherein the first lens group (G1) includes only lenses having positive refractive power, characterized in that the number of lenses of positive refractive power (L101-L103; L201-L202) of the first lens group (G1) is smaller than the number of lenses of positive refractive power (L116-L119; L215-L217) which are  
10 arranged forward of the diaphragm of the additional lens group (G5).

2. Projection objective of claim 1, characterized in that at least one of the lenses of the first lens group (G1) is an aspheric lens (L103, L201).

3. Projection objective of claim 1, characterized in that the first lens group (G1) has at least two positive lenses (L201 to L202, L101 - L103).

4. Projection objective of claim 1, characterized in that all of the lenses (L201 - L202, L101 - L103) of the first lens group (G1) are biconvex.

5. Projection objective of claim 2, characterized in that the asphericity of the aspheric lens (L103) in the first lens group (G1) deviates by more than 200  $\mu\text{m}$  compared to the best fitting spherical lens surface.

6. Projection objective according to at least one of the above claims, characterized in that the objective has a numerical aperture of at least 0.8, preferably 0.9.

7. Projection objective according to at least one of the above claims, characterized in that the lenses of the first and second lens groups except for the last lens of the second lens group (G2) all have almost identical diameters.

8. Projection objective according to at least one of the above claims, characterized in that the diameters of at least the first nine lens surfaces are almost the same size and are preferably less than a multiple of 1.3.

9. Projection objective of claim 14, characterized in that the approximately equal diameters (D1) of the lenses arranged at the object end are approximately half as large as the maximum diameters (D2) of the following lenses (L 120, L218).

10. Projection objective according to at least one of the above claims, characterized in that the projection objective is part of a projection exposure system for microlithography which preferably has an excimer laser as a light source for providing  
5 radiation needed for the projection exposure illumination, the radiation having a shorter wavelength than 250 nm.

11. Method for making microstructured components wherein a substrate, which is provided with a light-sensitive layer, is illuminated by ultraviolet laser light by means of a mask and a projection exposure system with a projection objective according

to at least one of the above claims 1 to 9 and the substrate is structured in correspondence to a pattern contained on the mask after the light-sensitive layer is developed.

Summary:Lithographic Objective having a First Lens Group including only  
Lenses having a Positive Refractive Power

(FIG. 2)

5           A projection objective includes a first lens group (G1) of  
positive refractive power, a second lens group (G2) of negative  
refractive power and at least one further lens group of positive  
refractive power in which a diaphragm is mounted. The first lens  
group (G1) includes exclusively lenses of positive refractive  
10           power. The number of lenses of positive refractive power (L101  
to L103; L201, L202) of the first lens group (G1) is less than  
the number of lenses of positive refractive power (L116 to L119;  
L215 to L217) which are mounted forward of the diaphragm of the  
further lens group (G5).